CS-543: Computer Vision Instructor: D.A. Forsyth
Homework 1

Instructions

This homework is a check, and should be done individually. It is due two and a half weeks from handout, i.e. 7 April. Submit by emailing a PDF to Alex. **Reminder:** Generally, we write a perspective camera in homogeneous coordinates as $\mathcal{CME}$, where $\mathcal{C}$ represents camera intrinsics, $\mathcal{M}$ is the matrix

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

and $\mathcal{E}$ is a rotation and translation.

Question 1:

We have two cameras $\mathcal{C}_1\mathcal{M}\mathcal{E}_1$ and $\mathcal{C}_2\mathcal{M}\mathcal{E}_2$. Corresponding to this pair of cameras is a *fundamental matrix*, $\mathcal{F}$, such that if $\mathbf{x}_1$ is the point in the left image corresponding to $\mathbf{x}_2$ in the right image, we have

$$\mathbf{x}_1^T \mathcal{F} \mathbf{x}_2 = 0$$

Derive an expression for $\mathcal{F}$ in terms of the $\mathcal{C}$'s and $\mathcal{E}$'s. You may look things up, etc.

Question 2:

In a single view, I am given three families of lines. All the lines in each family are parallel, so there is a vanishing point (which I know, or can construct) corresponding to each family. I can write a line in family 1 as $\mathbf{x} + t\mathbf{v}_1$, family 2 as $\mathbf{x} + t\mathbf{v}_2$, family 3 as $\mathbf{x} + t\mathbf{v}_3$. I know that $\mathbf{v}_1 \cdot \mathbf{v}_2 = 0$, $\mathbf{v}_1 \cdot \mathbf{v}_3 = 0$ and $\mathbf{v}_2 \cdot \mathbf{v}_3 = 0$. I know that the camera has square pixels, and the camera axes are at right angles, so that

$$\mathcal{C} = \begin{pmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & s \end{pmatrix}$$

Show how to recover $\mathcal{C}$ from this information.

Question 3:

I observe some points in a known (i.e. intrinsic parameters are calibrated) orthographic camera, then translate the camera parallel to the image plane with a known translation, and observe them again. Can I reconstruct these points in 3D? Why? In disgust, I throw away the orthographic camera, and obtain a known perspective camera. I repeat the experiment. Can I reconstruct these points in 3D now? why? **Hint:** this may be easier to answer with a drawing than with words.

Question 4:

In class, I described a factorization algorithm for recovering camera information and 3D point locations simultaneously from multiple images. In this algorithm, I assumed that the camera was orthographic and that all points were seen in all views. Now assume that some points are not seen in some views. How would one modify the algorithm to produce reasonable results?